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Kurashima

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(54) **OPTICAL TRANSCEIVER ADAPTED TO ANGLED POLISH CONNECTOR AND A METHOD TO ASSEMBLE THE SAME**

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G02B 6/42 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/4292*** (2013.01); ***G02B 6/423*** (2013.01); ***G02B 6/4256*** (2013.01); *G02B 6/421* (2013.01); *Y10T 29/49959* (2015.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,559,704 B2 *	7/2009	Togami	....	G02B 6/4219 385/88
2005/0180754 A1 *	8/2005	Mizue	....	G02B 6/4246 398/135
2005/0286839 A1 *	12/2005	Yoshikawa	....	G02B 6/4201 385/92

FOREIGN PATENT DOCUMENTS

JP 2005-181554 A 7/2005

* cited by examiner

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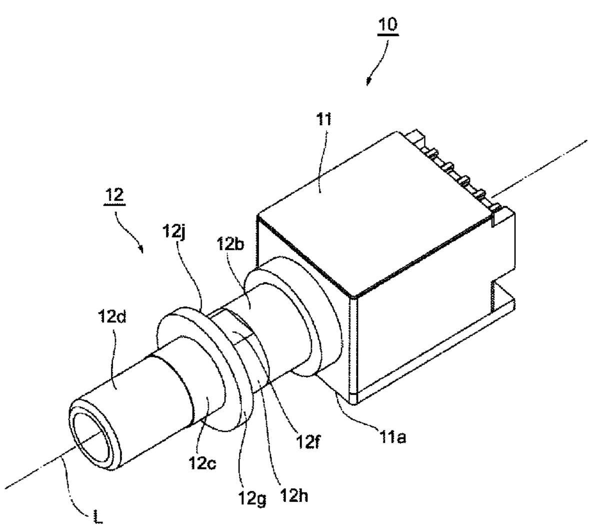
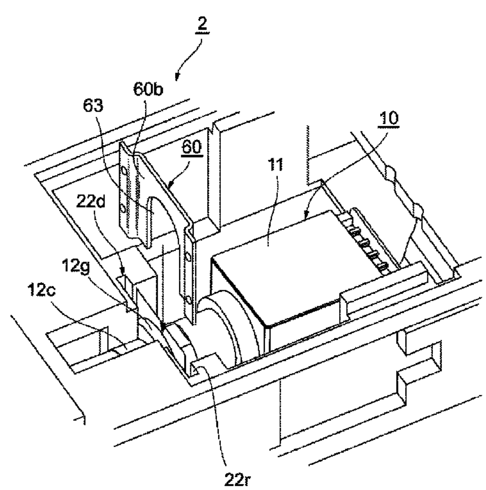
(57) **ABSTRACT**

An optical transceiver adapted to an optical connector having an angled physical contact (APC) is disclosed. The optical transceiver installs an optical sub-assembly to receive an external connector. The optical sub-assembly provides an index surface that indexes the inclined direction of the end of the stub abutting against the end surface of the external connector of the type of the APC. The housing provides a saddle with a flat surface on which the index surface of the optical sub-assembly is set.

11 Claims, 13 Drawing Sheets





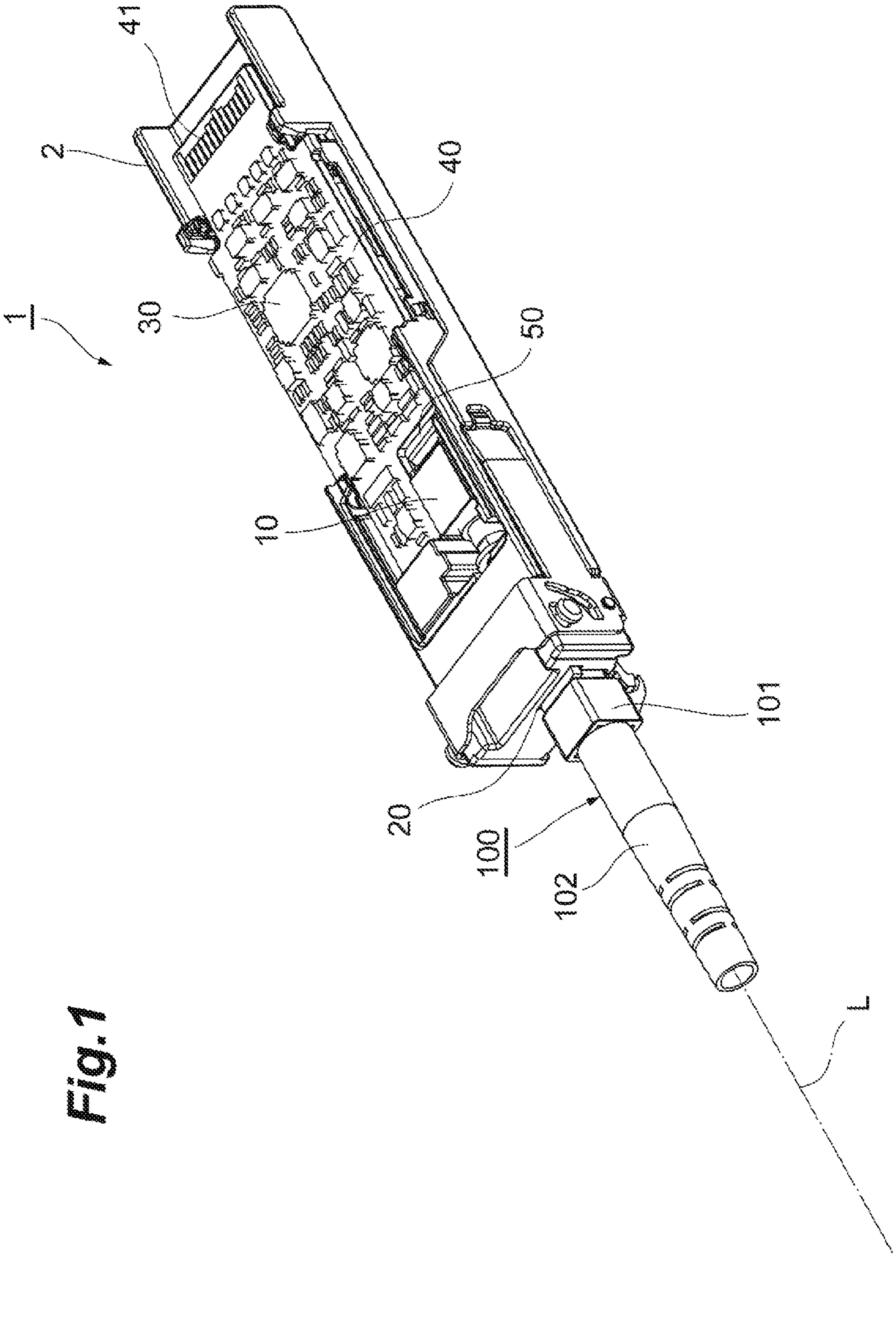


Fig.1

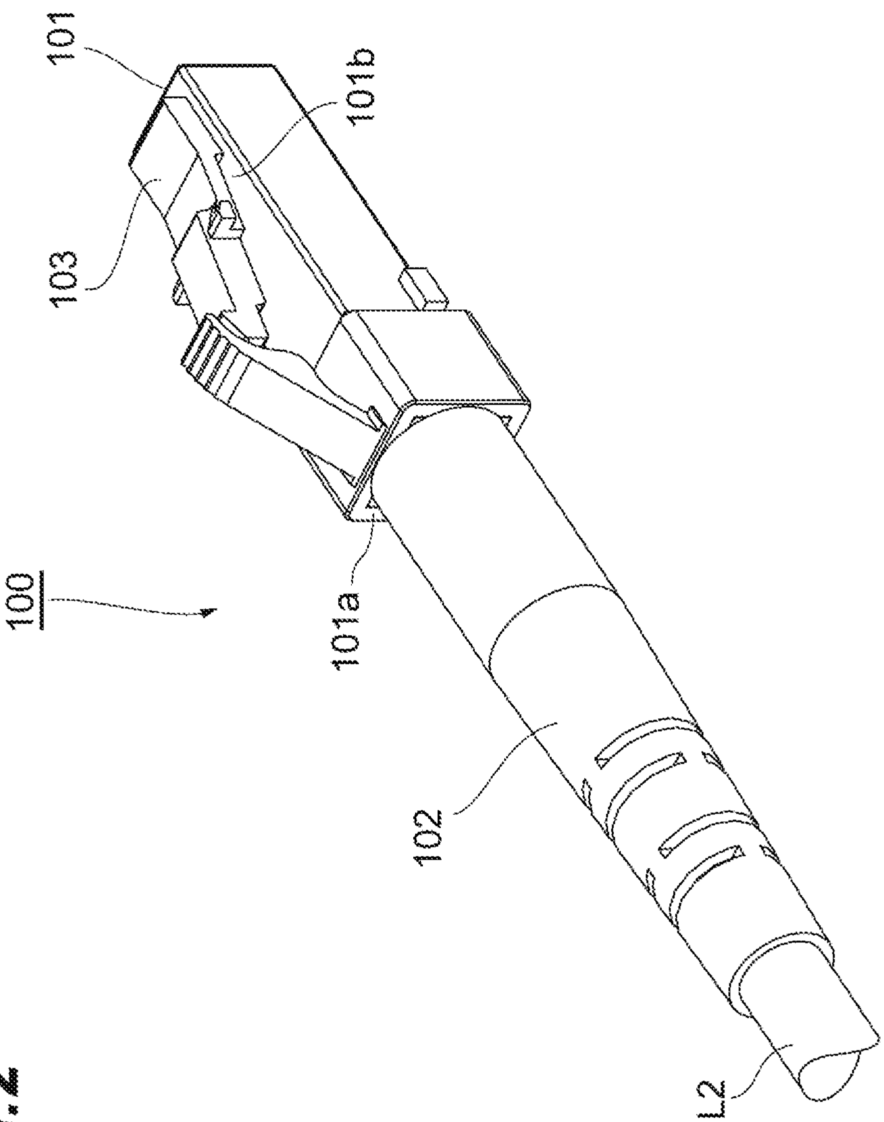


Fig.2

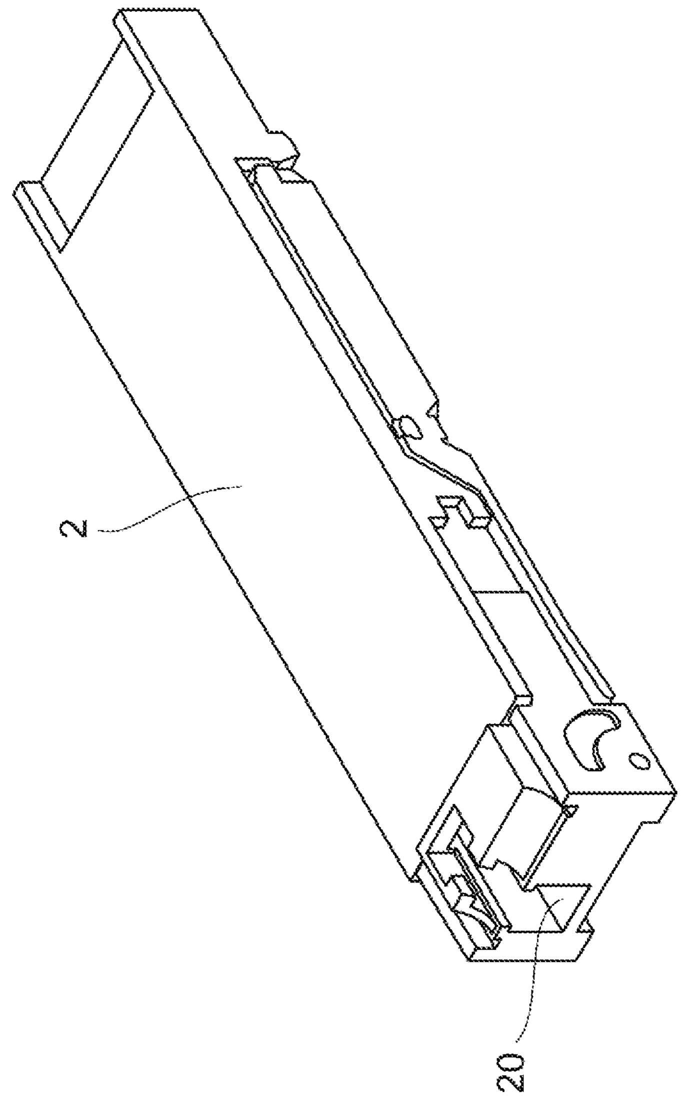


Fig.3

Fig.4

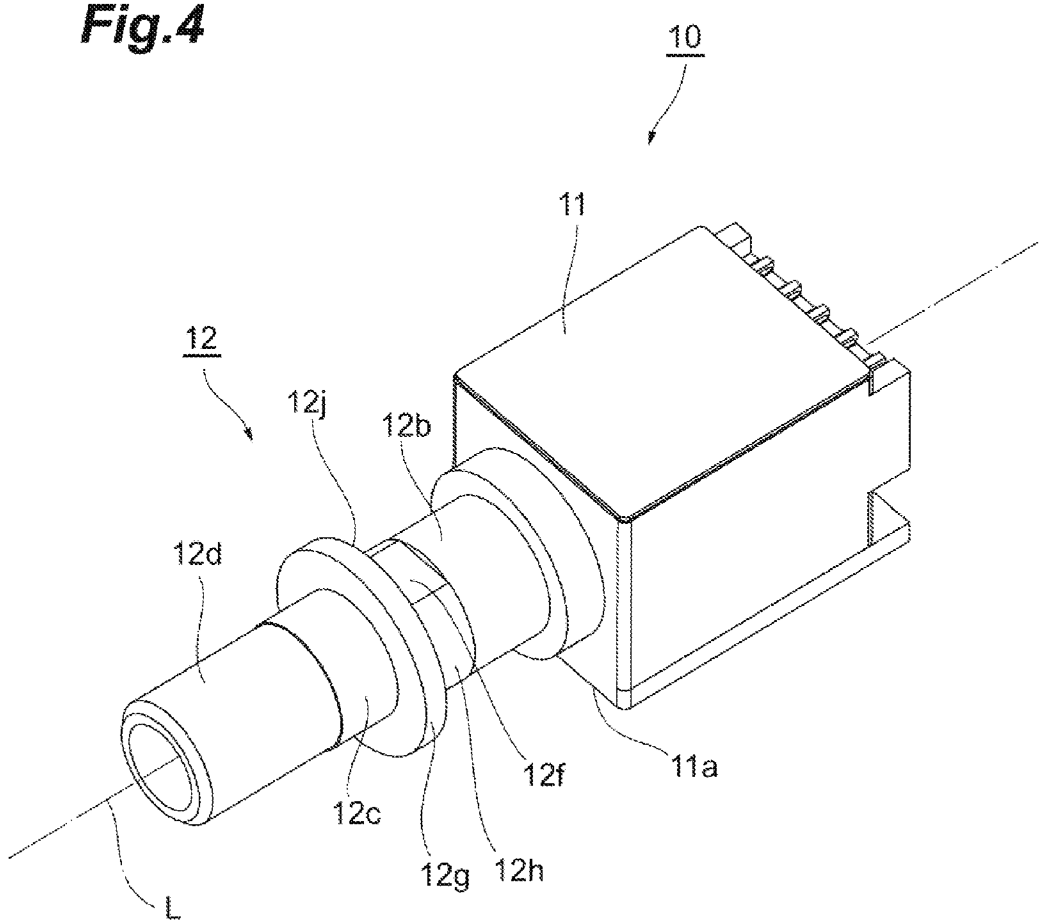
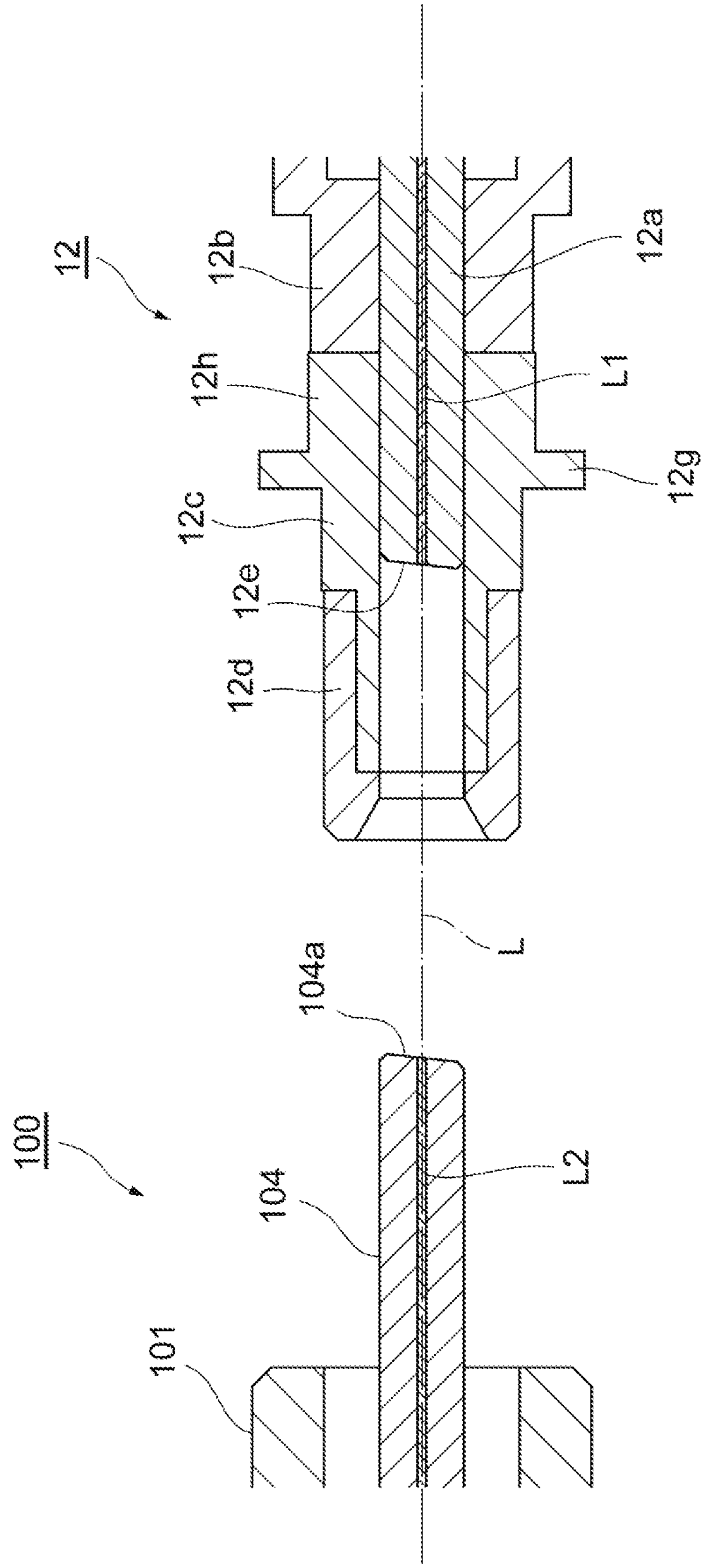


Fig.5



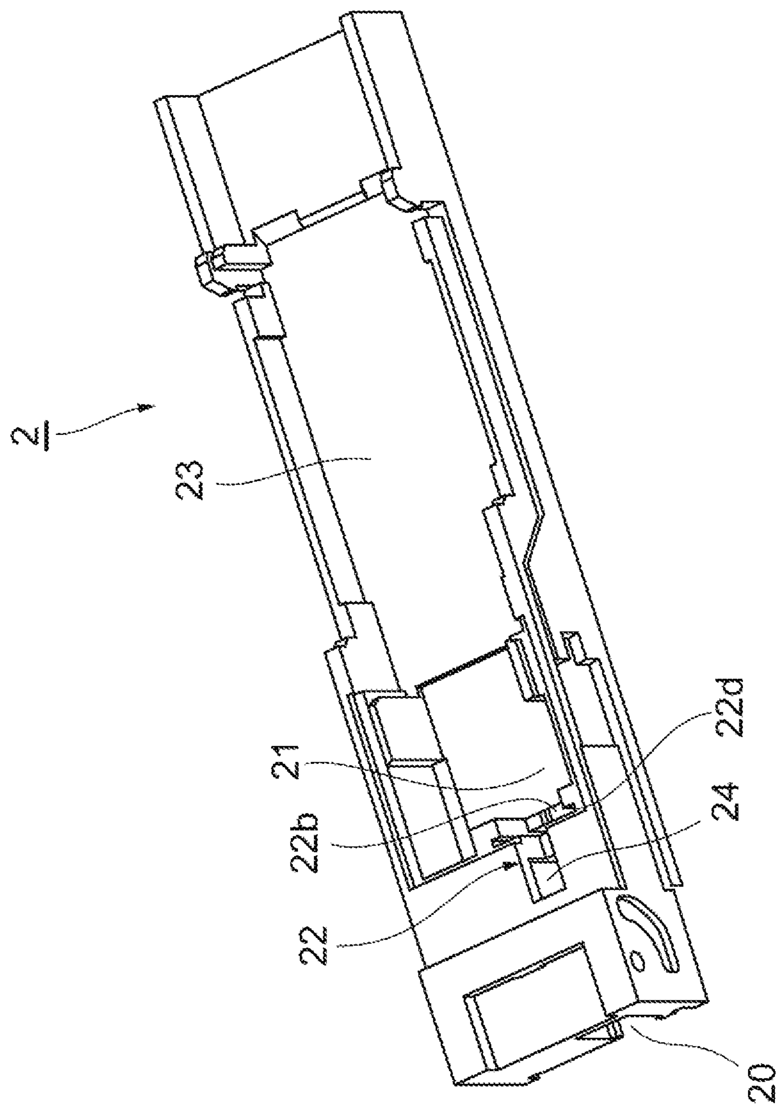


Fig.6

Fig.7

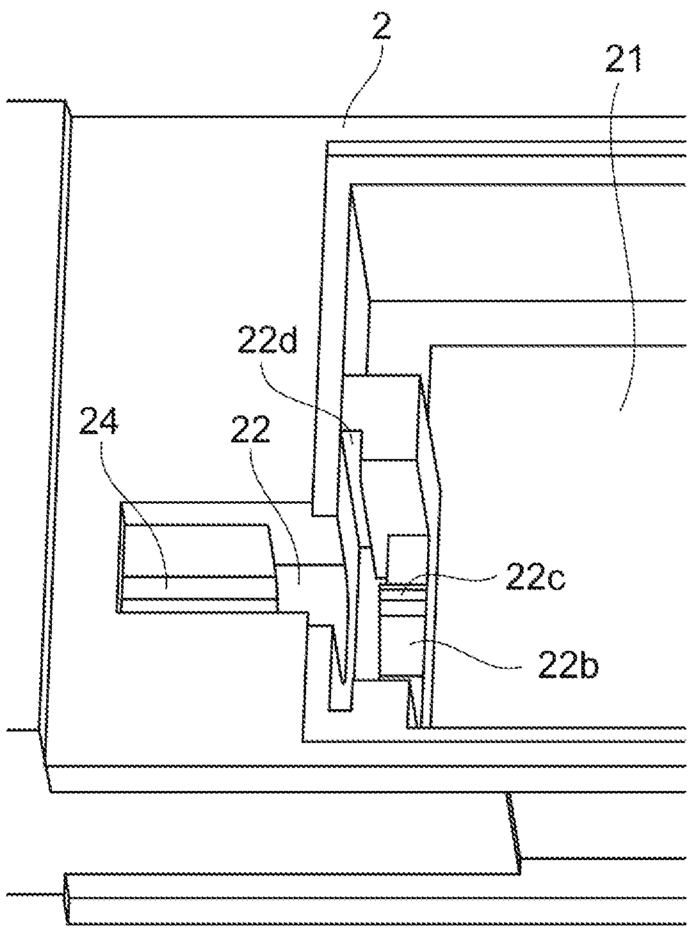


Fig.8

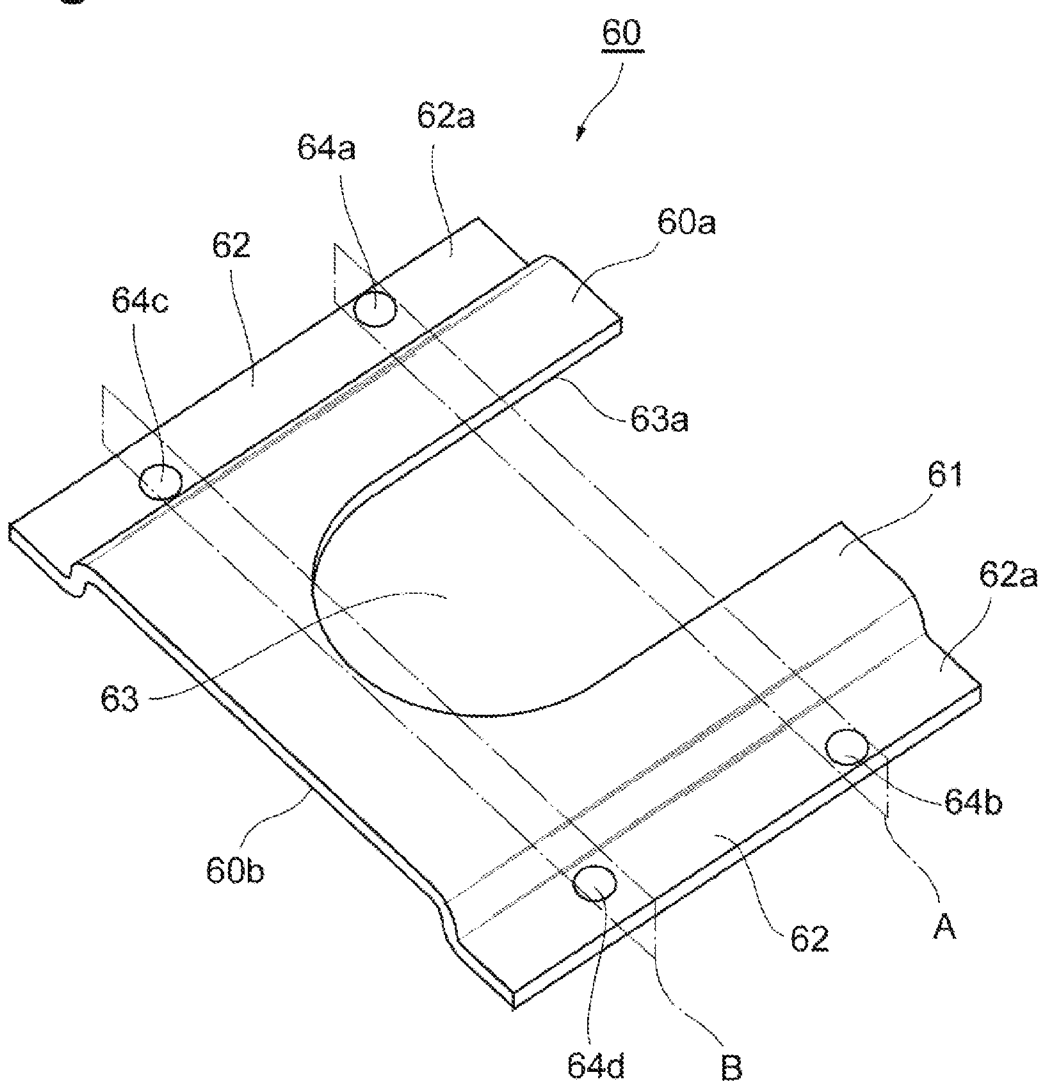


Fig.9

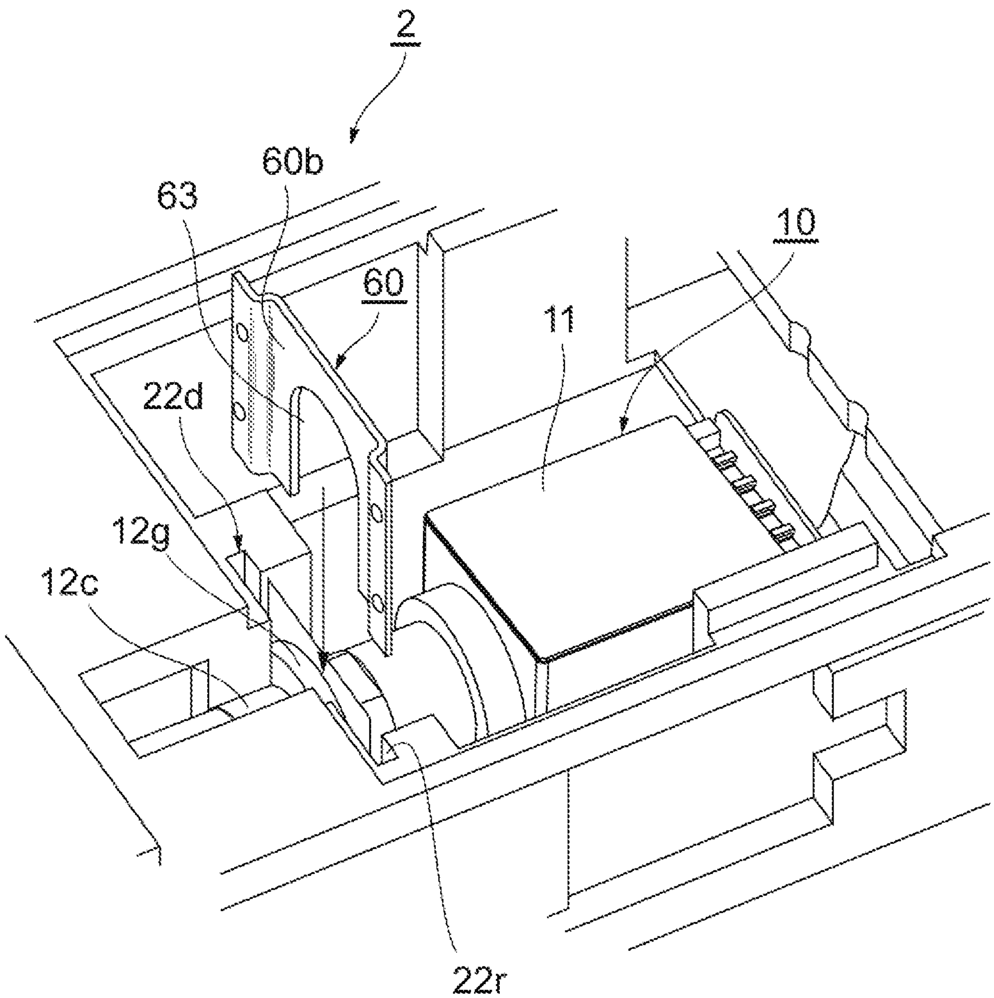


Fig.10A

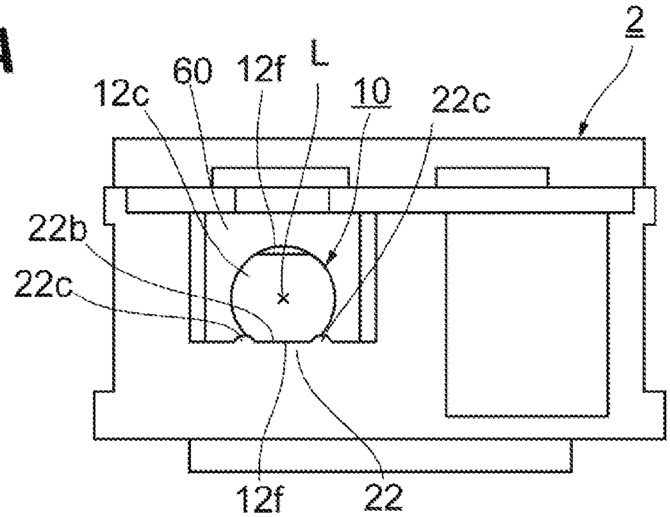


Fig.10B

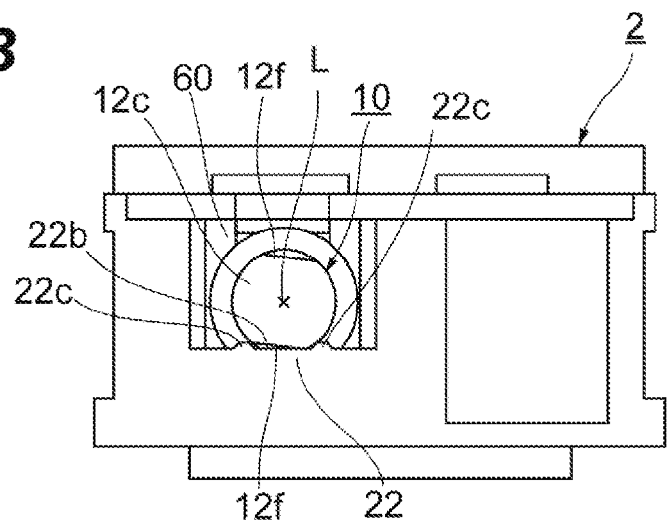


Fig.10C

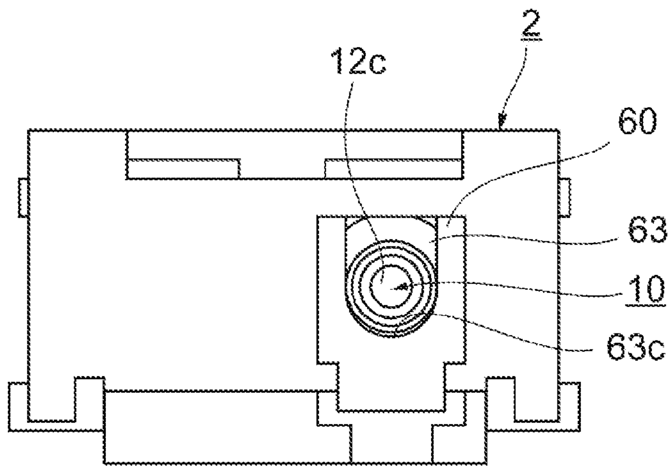


Fig.11

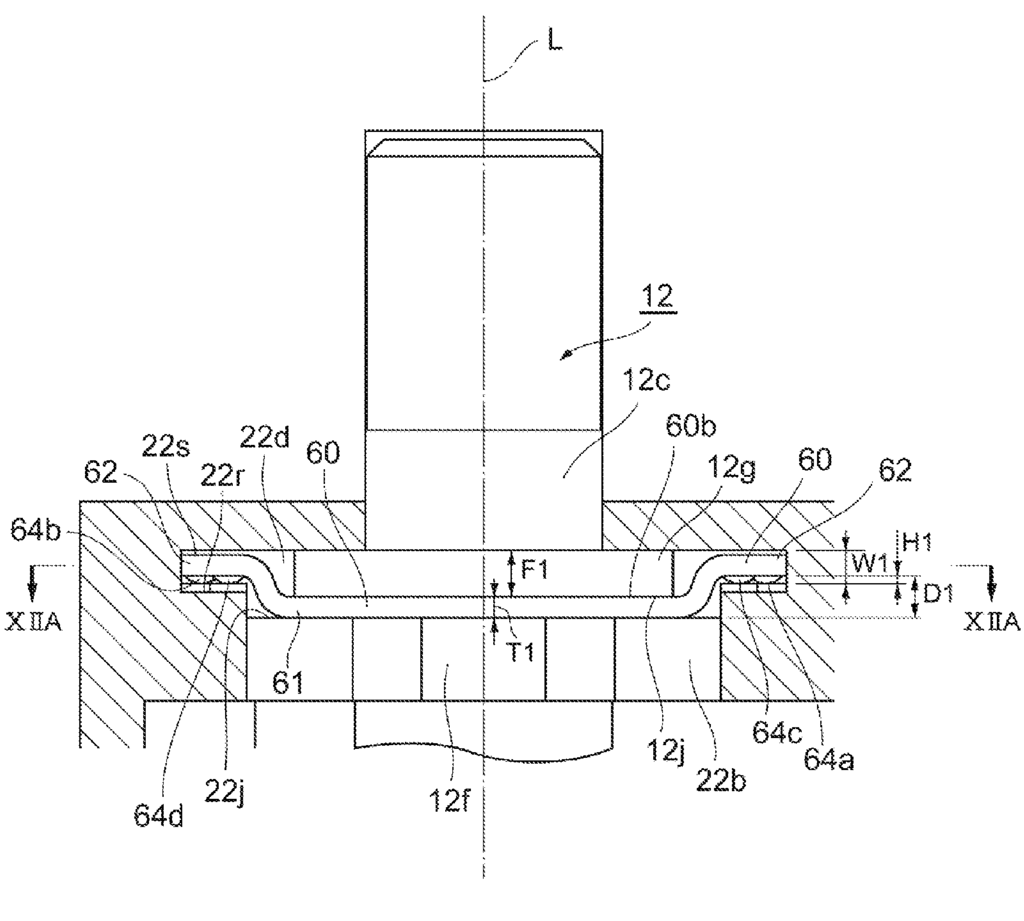

L
12
12c
60b
12g
60
62
22s
22d
22r
60
62
64b
W1
H1
F1
D1
XIIA
XIIA
T1
61
64c
64a
12j
22b
22j
64d
12f

Fig.12A

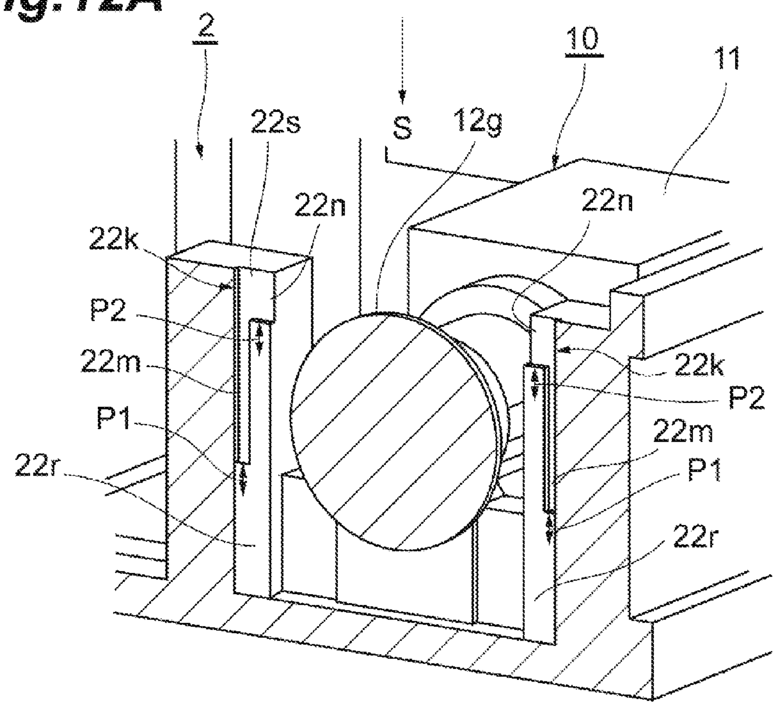


Fig.12B

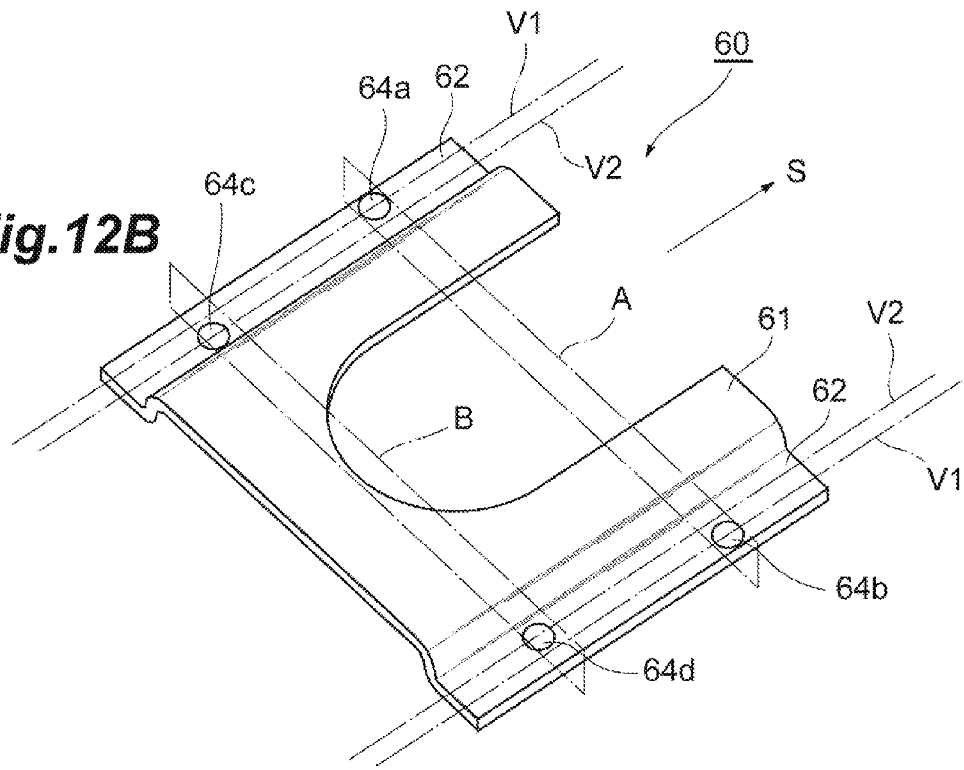
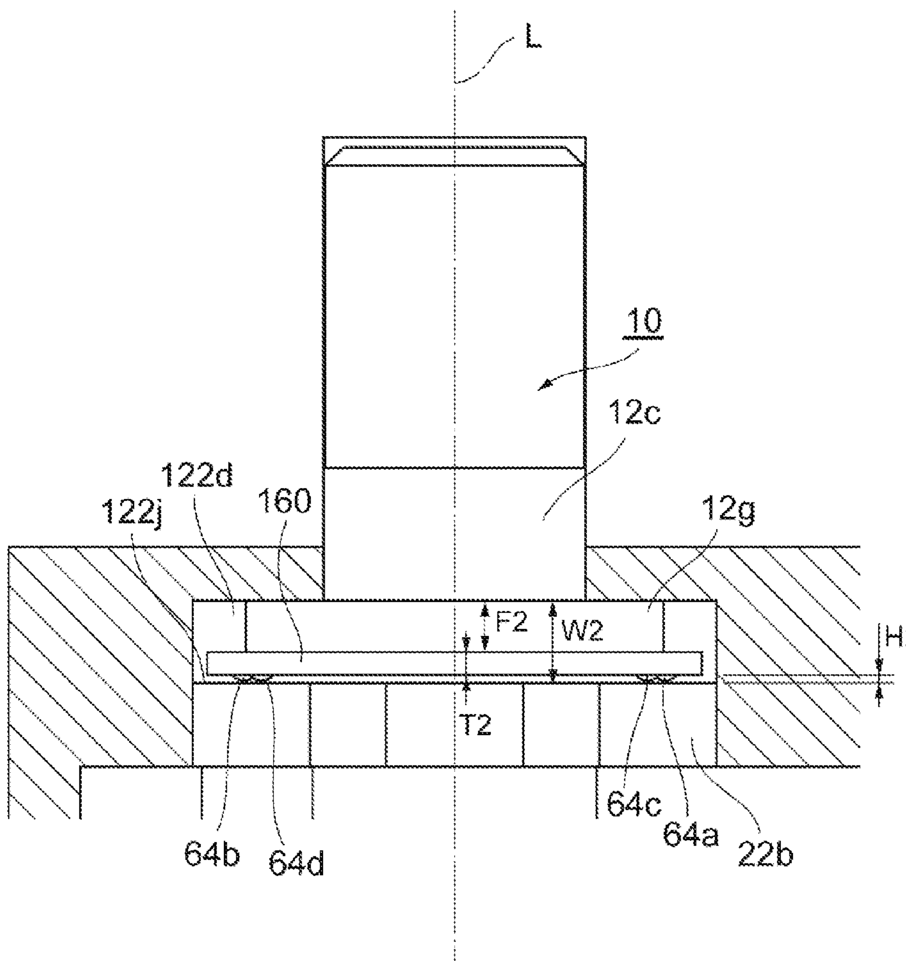


Fig.13



OPTICAL TRANSCEIVER ADAPTED TO ANGLED POLISH CONNECTOR AND A METHOD TO ASSEMBLE THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical transceiver, in particular, the invention relates to an optical transceiver adapted to receive a connector of the angled physical contact (APC).

2. Related Background Arts

A Japanese Patent application laid open No. 2005-181554A has disclosed an optical connector implementing with a split sleeve, where the split extends from an opening to the other opening of the cylindrical body. The split sleeve aligns an optical fiber inserted from one opening with another optical fiber inserted from the other opening by abutting the tip ends of the optical fibers in the split sleeve. Those optical fibers are secured with ferrules in respective ends. The tip end of the ferrule a formed in convex with the tip end of the fiber to facilitate the physical contact against another ferrule securing the optical fiber.

Another type of an optical connector implemented with a special ferrule, which is often called as the angled physical contact (APC), is well known in the field. The connector of the APC type includes a ferrule whose end surface is inclined against the optical axis thereof. Inclined end surface reflects light coming from the optical fiber secured in the ferrule toward an irregular direction. That is, the light propagating in the optical fiber is reflected at the end surface of the ferrule but not returns within the optical fiber.

However, when the inclined direction of the end surface of one fiber is misaligned with the inclined direction of the end surface of another fiber abutting against the one fiber, the optical coupling between two fibers may be degraded. Accordingly, in the connector of the APC type, the inclined direction of one fiber is necessary to be aligned with the inclined direction of another fiber within a specific tolerance.

SUMMARY OF THE INVENTION

One aspect of the present application relates to an optical transceiver adapted to receive an optical connector of the APC type. The optical transceiver of an embodiment provides an optical sub-assembly and a housing. The optical sub-assembly includes a cylindrical coupling portion and a box portion. The box portion encloses an optically active device to perform at least one of the optical transmission and the optical reception. The cylindrical coupling portion includes an index outer surface and secures a stub therein. The stub has an end surface inclined with respect to an optical axis of the stub. The index outer surface indexes an inclined direction of the end surface of the stub. The housing, which encloses the optical sub-assembly therein, provides a saddle in uniformly contact with the index outer surface of the coupling portion. Because the index outer surface is fully and uniformly in contact with the top surface of the saddle, the inclined direction of the stub is always aligned with respect to the housing. An external connector of the APC type may align the inclined direction of the ferrule thereof with the stub in the coupling portion.

Another aspect of the present application relates to a method to assemble an optical transceiver that provides an optical sub-assembly and a housing. The optical sub-assembly includes a cylindrical coupling portion that secures a stub having an end surface inclined with an optical axis thereof and has an index outer surface and a flange. The index outer surface indexes the inclined direction of the end surface of the stub. The housing provides a slot and a saddle. The method comprises, (1) installing the optical sub-assembly into the housing as inserting the flange into the slot of the housing; (2) rotating the cylindrical coupling portion around the optical axis such that the index outer surface is uniformly in contact with the top surface of the saddle; and (3) inserting a holder into a gap between the flange and a wall forming the slot such that the holder pushes the flange against another wall forming the slot.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other purposes, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

FIG. **1** is a perspective view showing an inside of the optical transceiver according to an embodiment of the invention;

FIG. **2** is a perspective view of an optical connector to be mated with the optical transceiver shown in FIG. **1**;

FIG. **3** shows an outer appearance of the optical transceiver shown in FIG. **1**;

FIG. **4** shows an outer appearance of an optical sub-assembly to be installed within the optical transceiver shown in FIG. **1**;

FIG. **5** schematically shows cross sections of the optical connector shown in FIG. **2** and a coupling portion of the optical sub-assembly shown in FIG. **4**;

FIG. **6** is a perspective view of a housing of the optical transceiver shown in FIG. **3**;

FIG. **7** magnifies a front portion of the housing where the optical sub-assembly shown in FIG. **4** is to be installed;

FIG. **8** is a perspective view of a holder to be set into a slot of the front portion of the housing;

FIG. **9** shows a process to set the holder shown in FIG. **8** into the slot of the housing to fix the coupling portion of the optical sub-assembly shown in FIG. **4** in the front portion of the housing shown in FIG. **7**;

FIG. **10**A shows a status where the coupling portion of the optical sub-assembly set regularly in the housing, FIG. **10**B shows another status where the coupling portion of the optical sub-assembly set irregularly in the housing, and FIG. **10**C views, from the side of the optical receptacle, the coupling portion irregularly set in the housing;

FIG. **11** is a plan view of the coupling portion of the optical sub-assembly set in the housing as putting the holder into a gap to secure the coupling portion rigidly;

FIG. **12**A is a cross sectional view of the coupling portion of the optical sub-assembly shown in FIG. **4** set in the slot of the housing, and FIG. **12**B shows the holder shown in FIG. **8** again; and

FIG. **13** is a plan view of the coupling portion of the optical sub-assembly shown set in the housing but as putting another type of holder into the gap to secure the coupling portion rigidly.

DESCRIPTION OF EMBODIMENTS

Next, some embodiments of the present invention will be described as referring to accompany drawings. In the description of the drawings, numerals or symbols same with or similar to each other will refer to elements same with or similar to each other without duplicated explanations.

FIG. **1** is a perspective view showing an inside of an optical transceiver **1** according to an embodiment of the present invention, FIG. **2** is also a perspective view showing an embodiment of an optical connector **100** mated with the optical transceiver **1** shown in FIG. **1**, and FIG. **3** is an outer appearance of the optical transceiver **1**. The optical transceiver **1** of the present invention provides a housing **2**, an optical sub-assembly (OSA) **10**, an optical receptacle **20**, electronic circuits **30**, a printed circuit board (PCB) **40**, and a flexible printed circuit (FPC) board **50**. The optical transceiver **1** may be a pluggable optical transceiver, where some of specifications thereof follow one of multi-source agreement (MSA) called the XFP. An optical transceiver is featured to have function of the optical transmission and the optical reception to perform the full-duplex optical communication using a pair of optical fibers. The present specification concentrates on the optical transmission, but sprits of the present invention may be applicable to the optical reception.

As shown in FIGS. **1** and **2**, the optical receptacle **20**, which is provided in one longitudinal end of the optical transceiver **1**, receives an external optical connector **100** to couple the OSA **10** optically with an external optical fiber L2 secured in the optical connector **100**. The optical connector **100** provides a box-shaped housing **101** and a cylindrical boot **102** attached to one side **101**_a_ of the box-shaped housing **101**. The external optical fiber L2 passes through the housing **101** and the cylindrical boot **102**. A top of the box-shaped housing **101** provides a grip **103** extending outwardly. Setting the grip **103** within a wall of the optical receptacle **20**, the optical connector **100** may be latched with the optical receptacle **20**.

Referring to FIG. **1**, the electronic circuits **30** are mounted on the PCB **40** and drives the OSA **10**. The electronic circuits **30** include a driver to drive optical devices installed within the OSA **10**. The OSA **10** is electrically connected to the circuits **30** on the PCB **40** through the FPC board **50**. A rear portion of the PCB **40** provides an electrical plug **41** to communicate with the external host system.

FIG. **4** shows an outer appearance of the OSA **10**. The OSA **10**, which transmits an optical signal externally, provides a box portion **11** to install optical devices such as a light-emitting device therein and a coupling portion **12** to couple the optical devices in the box portion with the optical fiber L2. The coupling portion **12** has a cylindrical shape.

As shown in FIGS. **4** and **5**, the coupling portion **12** provides, from the side of the box portion **11**, a stub **12**_a_, a bush **12**_b_, a sleeve **12**_c_, and a cover **12**_d_. The stub **12**_a_ secures a coupling fiber L1 in a center thereof, which is the type of the single mode fiber. A feature of the stub **12**_a_ of the embodiment is that the tip end **12**_e_ of the stub **12**_a_ exposes an end of the coupling fiber L1, and this end surface **12**_e_ accompanied with coupling fiber L1 is inclined with respect to an optical axis L of the coupling fiber L1 to form, what is called, the angled physical contact (APC) surface.

The sleeve **12**_c_ secures an end portion of the stub **12**_a_, and a root portion of the stub **12**_a_ is supported by the bush **12**_b_. The sleeve **12**_c_ has a cylindrical shape with a bore into which the end portion of the stub **12**_a_ and a ferrule **104** of the external optical connector **100** is inserted. The sleeve **12**_c_ also provides in an outer surface thereof a flange **12**_g_, two index surfaces **12**_f_ in a side **12**_h_ closer to the box portion **11** from the flange **12**_g_. Two index surfaces **12**_f_, which are symmetrically formed with respect to the axis L of the stub **12**_a_, become reference surfaces to form the inclined end surface **12**_e_ of the stub **12**_a_.

The optical connector **100** provides the ferrule **104** to be inserted within the bore of the sleeve **12**_c_. The ferrule **104** secures the external optical fiber L2 in a center thereof. The end surface **104**_a_ of the ferrule **104** exposes the tip end of the external fiber L2 and is inclined, accompanied with the end surface of the external fiber L2, with respect to the axis of the external fiber L2 to form the APC structure.

As described, the ferrule **104** is mated with the sleeve **12**_c_. Specifically, the ferrule **104** is inserted within the bore of the sleeve **12**_c_. Inserting the ferrule **104** into the bore of the sleeve **12**_c_ and abutting the end surface **104**_a_ thereof against the end surface **12**_e_ of the stub **12**_a_, the optical coupling between the coupling fiber L1 and the external fiver L2 may be realized. When the inclined direction of the end surface **104**_a_ of the ferrule **104** is misaligned with the inclined direction of the end surface **12**_e_ of the stub **12**_a_, a gap is formed between two fibers, L1 and L2, which increases the optical coupling loss therebetween. Even when the inclined direction of the end surface **104**_a_ of the ferrule **104** is misaligned with the inclined direction of the end surface **12**_e_ of the stub **12**_a_, the inclined directions of the end surfaces, **104**_a_ and **12**_e_, are automatically aligned when the misalignment between the inclined directions of two surfaces, **104**_a_ and **12**_e_, is within a preset range, which is called as the auto-alignment of end surfaces, **104**_a_ and **12**_e_. Accordingly, the optical connector **100** is necessary to be inserted into the optical receptacle **20** as roughly aligning the inclined directions of the end surfaces, **104**_a_ and **12**_e_.

Next, a mechanism to align the inclined directions of two end surfaces, **104**_a_ and **12**_e_, roughly will be described.

FIG. **6** shows an inside of the housing **2** and FIG. **7** magnifies a primary portion of the housing **2**. The housing **2** provides the optical receptacle **20**, a box pocket **21** into which the box portion **11** of the OSA **10** is placed, a sleeve pocket **22** into which the coupling portion **12** is set, and a PCB pocket **23** into which the PCB **40** is placed. The box pocket **21** and the sleeve pocket **22** are provided in just a rear of the optical receptacle **20**, and the PCB pocket **23** is formed in a rear of the box pocket **21**. The sleeve pocket **22** provides a saddle **22**_b_ to align the inclined direction of the end surface **12**_e_.

Further specifically, the sleeve pocket **22** provides the cut **24**. Inserting the sleeve **12**_c_ of the OSA **10** into the cut **24**, the coupling portion **12** of the OSA **10** is easily set within the housing **2**. Also, referring to FIGS. **7** and **10**A to **10**C, the saddle **22**_b_, onto which the index surface **12**_f_ is set, is provided in the rear of the cut **24** so as to truncate the cut **24**. The saddle **22**_b_ provides ribs **22**_c_ in both sides of a portion where the index surface **12**_f_ comes in contact. Moreover, provided between the cut **24** and the saddle **22**_b_ is a slot **22**_d_ into which the flange **12**_g_ and a holder **60** are inserted to fix the OSA **10**.

FIG. **8** is a perspective view of the holder **60**. The holder **60** may be formed by cutting and bending a metal plate. As shown in FIG. **8**, the holder **60** has a rectangular plane shape with a terraced center portion **61** and hollowed side portions **62**. The terraced center portion **61** provides a U-shaped cut **63** through which the sleeve **12**_c_ of the coupling portion **12** passes.

Passing the sleeve **12**_c_ through the cut **63**, the flange **12**_g_ is in contact with a hollowed surface **60**_b_ of the terraced center portion **61**, the neck **12**_h_ behind the flange **12**_g_ is set in the edges **63**_a_ of the cut **63**, and the inner surface **12**_j_ of the flange **12**_g_, which faces the box portion **11**, comes in contact with the hollowed surface **60**_b_.

The surfaces **62**_a_ of respective hollowed side portions **62** provide four projections, **64**_a_ to **64**_d_, each having a size and a shape substantially same with others. Respective tops of the projections **64***a* to **64***d* abut against the rear wall **22***r* of the slot **22***d* when the holder **60** is set in the slot **22***d*.

The embodiment of the holder **60** illustrated in FIG. **8** provides the terraced center portion **61**, the hollowed side portions **62**, and steps between two portions, **61** and **62**. However, the holder **60** may have an arrangement without steps. That is, a holder with no terraced center portion and two hollowed side portions **62**. FIG. **13** is a top view showing another arrangement of the holder **160**. The holder **160** shown in FIG. **13** is formed by cutting a metal plate but without any bending to form the terraced center portion **61** and two hollowed side portions **62**. The holder **160** shown in FIG. **13** also provides four projections **64***a* to **64***d* in respective two sides. Setting the holder **160** between the flange **12***g* and the front wall **122***j* of the saddle **22***b*, the projections, **64***a* to **64***d*, abut against the front wall **122***j* of the saddle **22***b*, and are partially crashed so as to press the holder **160** and the flange **12***g* forwardly, thus, the coupling portion **12** is rigidly fixed in the housing **2**.

FIG. **9** magnifies the box pocket **21** and the box portion **11** set in the box pocket **21**. FIGS. **10**A to **10**C show statuses of the OSA **10** rotating around the axis L of the coupling portion **12**, where FIGS. **10**A and **10**B view the coupling portion **12** from the rear of the housing **2**, while, FIG. **10**C views the sleeve **12***c* from the front.

When the OSA **10** is installed within the housing **2**, the flange **12***g* of the coupling portion **12** is first set within the slot **22***d*. When the rotational angle around the optical axis L of the coupling portion **12** is misaligned from the designed one, which causes a gap between the index surface **12***f* of the coupling portion **12** and the top of the saddle **22***b*, the OSA **10** may be rotated around the axis L such that the index surface **12***f* comes in closely contact with the top of the saddle **22***b* as shown in FIG. **10**A.

Then, the holder **60** is set in the slot **22***d* such that the projections, **64***a* to **64***d*, of the holder **60** abut against the rear wall **22***r* of the side spaces **22***s* of the slot **22***d*, which pushes the flange **12***g* forward so as to abut against the front wall of the slot **22***d*. Thus, the OSA **10** is installed in the housing **2** as adjusting the rotational angle of the coupling portion **12** by making the index surface **12***f* of the coupling portion **12** in uniformly contact with the top of the saddle **22***b*. In such a state, inserting the external connector **100** securing the ferrule **104**, whose end surface **104***a* is also inclined, into the optical receptacle **20** regularly, the inclined direction of the end surface **12***e* of the stub **12***a* and that of the end surface **104***a* of the ferrule **104** may be roughly aligned.

When the rotational angle of the coupling portion **12** is deviated from the designed angle, which means that the index surface **12***f* is not uniformly in contact with the top of the saddle **22***b* and the sleeve **12***c* forms a gap against the edge **63***a* of the U-shape cut **63**. This gap may be easily recognized by inspecting the coupling portion **12** from the optical receptacle **20** by measuring a distance from the periphery of the sleeve **12***c* to the edge **63***a* of the U-shaped cut **63**.

FIG. **11** is a plan view of the coupling portion **12** whose flange **12***g* is set within the slot **22***d*. As shown in FIG. **11**, the holder **60** is set between the flange **12***g* and the front wall **22***j* of the saddle **22***b*, where the front wall **22***j* of the saddle **22***b* constitutes rear wall forming the slot **22***d*. Also, the slot **22***d* provides side spaces **22***s* with a narrowed width in respective ends. The hollowed side portions **62** of the holder **60** is set in the side spaces **22***s* as abutting the projections, **64***a* to **64***d*, against the rear wall **22***r* of the side spaces **22***s*. The terraced center portion **61** of the holder **60** is set between the flange **12***g* and the saddle **22***b* in the center portion of the slot **22***d* that has a widened width compared to that of the side spaces **22***s*.

Assuming a thickness of the flange **12***g*, a width of the side spaces **22***s* of the slot **22***d*, a thickness of the holder **60**, a step between the side spaces **22***s* and the center portion of the slot **22***d*, and heights of the projections, **64***a* to **64***d*, are F1, W1, T1, D1, and H1, respectively; the following relation is necessary to be satisfied to make the projections, **64***a* to **64***d*, rigidly in contact with the rear wall **22***r* of the side spaces **22***s* of the slot **22***d* and securely fix the flange **12***g* within the slot **22***d*:

$$F1+T1+H1-D1>W1. \tag{1}$$

Setting a dimension of a sum of F1, T1, and H1 subtracting D1 to be greater than W1, the projections, **64***a* to **64***d*, are securely abut against the rear wall **22***r* of the side spaces **22***s* of the slot **22***d*, and the terraced center portion **61** of the holder **60** pushes the rear surface of the flange **12***g* forward such that the front surface of the flange **12***g* is pushed against the front wall of the slot **22***d*.

When the holder **60** is inserted in a gap between the flange **12***g* and the front wall **22***j* of the saddle **22***b*; the projections, **64***a* to **64***d*, in the hollowed side portions **62** slide on the rear wall **22***r* of the side spaces **22***s* of the slot **22***d* as crushing the tops thereof. In the same time, the rear walls **22***r* of the side spaces **22***s* abrade. The present optical transceiver **1** has a mechanism to reduce the abrasion of the rear wall **22***r* of the side spaces **22***s*.

FIG. **12**A shows a cross section taken along the line XIIA-XIIA appearing in FIG. **11**, and FIG. **12**B illustrates the holder **60** again, which is substantially same with that shown in FIG. **8**. The projections, **64***a* to **64***d*, are divided into two groups, A and B. The group A includes the projections, **64***a* and **64***b*, where they first abut against the rear wall **22***r* of the side spaces **22***s* when the holder **60** is inserted in the slot **22***d*. The group B includes the projections, **64***c* and **64***d*. Two projections, **64***a* and **64***c*, provided in one of the hollowed side portions **62** are offset with respect to the inserting direction S of the holder **60**. Also, rest projections, **64***b* and **64***d*, provided in the other hollowed side portion **62** are offset with respect to the inserting direction S. The projections, **64***a* and **64***b*, in the group A is provided outside compared with the projections, **64***c* and **64***d*, in the group B. Further specifically, the projections, **64***a* and **64***b*, in the group A are set on lines V1, while, the rest projections, **64***c* and **64***d*, are set on other lines V2; and the lines V1 is drawn outside of the lines V2.

On the other hand, the rear walls **22***r* of the side spaces **22***s* of the slot **22***d* provide L-shaped hollows **22***k*. The hollow **22***k* includes two areas, **22***m* and **22***n*, where the former is extended along the insertion direction S of the holder **60**, while, the latter extends laterally with respect to the insertion direction S.

When the holder **60** is inserted into the slot **22***d*, the projections, **64***a* and **64***b*, in the group A slide in the former area **22***m*, while, the other projections, **64***c* and **64***d*, in the group B slide in the other area **22***n*. The projections, **64***a* to **64***d*, make a gap against the rear wall **22***r* of the side spaces **22***s* when they slide in the respective areas, **22***m* and **22***n*. That is, the projections, **64***a* to **64***d*, in respective tips thereof are apart from the rear wall **22***r* of the side spaces **22***s* when they slide in respective areas, **22***m* and **22***n*. Further inserting the holder **60** into the slot **22***d*, the projections, **64***a* and **64***b*, in the group A ride on the step **22***k*, while, the other projections, **64***c* and **64***d*, in the group B also ride on the step

22*k*. Then, the projections, 64*a* to 64*d*, abut against the rear wall 22*r* of the side spaces 22*s*.

Under such an arrangement of the projections, 64*a* to 64*d*, and the step 22*k*, a distance P1 from the edge of the step 22*k* to a position, at which the projections, 64*a* and 64*b*, in the first group A stop, is substantially equal to a distance P2 from the edge of the step 22*k* in the area 22*n* to a position at which the projections, 64*c* and 64*d*, stop. Thus, the arrangement of the rear wall 22*r* of the side spaces 22*s* and the projections, 64*a* to 64*d*, of the holder 60 may shorten the length where the projections, 64*a* to 64*d*, slide not only for the projections, 64*c* and 64*d*, in the group B but for the projections, 64*a* and 64*b*, in the first group A. Also, the abrasion of the rear wall 22*r* of the side spaces 22*s* may be reduced.

When the index surface 12*f* in the coupling portion 12 is not formed in parallel to the bottom surface 11*a* of the box portion 11, the bottom surface 11*a* does not always come in contact with the bottom of the housing 2 even in the rotation angle of the sleeve 12*c* is aligned by making the index surface 12*f* in uniformly contact with the top of the saddle 22*b*. The bottom surface 11*a* of the box portion 11 often forms a gap against the bottom of the housing 2. The present optical transceiver 1 rigidly fixes the OSA 10 by setting the flange 12*g* of the coupling portion 12 in the slot 22*d* of the housing 2 and inserting the holder 60 between the flange 12*g* and the front wall 22*j* of the saddle 22*b*, which is unnecessary to secure the box portion 11 against the housing 2.

Also, when the OSA 10 in the box portion 11 thereof is set in the box pocket 21 and in the coupling portion 12 thereof is set within the sleeve pocket 22 as rotating the coupling portion 12 and the box portion 11 around the optical axis L such that the index surface 12*f* of the coupling portion 12 comes in uniformly contact with the top of the saddle 22*b*; the end surface 12*e* of the stub 12*a* in the inclined direction thereof may be roughly aligned with the inclined direction of the end surface 104*a* of the ferrule 104.

Moreover, the top of the saddle 22*b* provides a pair of ribs 22*c* putting the index surface 12*f* therebetween. When the coupling portion 12 is erroneously rotated, the index surface 12*f* rides on the rib 22*c* which lifts the coupling portion 12 upward to form a gap between the edge 63*a* of the cut 63 and the sleeve 12*c*. Because this status of the lifted coupling portion 12 may be easily and visually inspected, the assembling of the OSA 10 into the housing 2 is facilitated. Two ribs 22*c*, when the index surface 12*f* is properly set therebetween, may hold the index surface 12*f* stably, which enhances the tolerance against an unintentional rotation of the coupling portion 12.

Thus, the inventions of the present application are described as referring to exemplary drawings. The present inventions, however, are not restricted to those embodiments. It would be easily understood by an ordinary artisan in the field that many changes and modifications for such embodiments are applicable.

For instance, as shown in FIG. 13, the optical transceiver 1 may provide another type of slot 122*d* and the holder 160. The slot 122*d* shown in FIG. 13 provides no side spaces 22*s* but has a constant width. However, the holder 160 provides no terraced center portion 61 and no hollowed side portions 62. The holder 160 shown in FIG. 13 is made of a plane slab. Assuming a thickness of the flange 12*g*, a width of the slot 122*d*, a thickness of the holder 160, and heights of the projections, 64*a* to 64*d*, are F2, W2, T2, and H2, respectively; the next relation may be satisfied to securely fix the flange 12*g* within the slot 122*d*:

$$F2+T2+H2>W2. \tag{2}$$

Setting the physical dimensions of the members above so as to satisfy the relation, the stress felt by the projections, 64*a* to 64*d*, from the front wall 122*j* of the saddle 22*b*, the pressure between the holder 160 and the flange 12*g*, and the pressure between the flange 12*g* and the front wall of the slot 122*d* may be secured.

Also, the explanation above concentrates the OSA 10 having the box portion 11. However, the present optical transceiver 1 does not restrict the OSA with the box portion 11. For instance, the optical transceiver 1 of the present invention may install an OSA having a co-axial package. Although the co-axial package never comes in stably and uniformly contact with the bottom of the housing 2, the present optical transceiver 1 provides the slot 22*d* to receive the flange 12*g* of the OSA 10 and the holder 60 to fill a gap between the flange 12*g* and the slot 22*d*. Thus, the OSA 10 may be securely and stably installed within the housing 2 of the optical transceiver 1.

What is claimed is:

1. An optical transceiver, comprising:
an optical sub-assembly including a cylindrical coupling portion and a box portion, the box portion enclosing an optically active device, the cylindrical coupling portion including an index outer surface and securing a stub with an end surface inclined with respect to an optical axis of the stub, the index outer surface indexing an inclined direction of the end surface of the stub; and
a housing that encloses the optical sub-assembly therein, the housing providing a saddle being in uniformly contact with the index outer surface of the coupling portion.

2. The optical transceiver of claim 1,
wherein the saddle of the housing provides a pair of ribs setting the index outer surface of the coupling portion therebetween.

3. The optical transceiver of claim 1,
wherein the coupling portion further includes a sleeve configured to receive a ferrule of an external optical connector, the ferrule having an end surface inclined with respect to the optical axis, and
wherein the end surface of the ferrule has an inclined direction equal to an inclination direction of the end surface of the stub.

4. The optical transceiver of claim 1,
further comprising a holder,
wherein the coupling portion further includes a flange and the housing further includes a slot configured to receive the flange of the coupling portion, and
wherein the holder fills a gap between the flange and a wall forming the slot.

5. The optical transceiver of claim 4,
wherein the holder pushes the flange of the coupling portion toward a side opposite to the index outer surface with respect to the flange.

6. The optical transceiver of claim 5,
wherein the sub-assembly is secured only by setting the flange into the slot as the holder filling the gap, and the box portion is apart from the housing.

7. The optical transceiver of claim 4,
wherein the holder has a projection crashed by abutting against the wall forming the slot.

8. The optical transceiver of claim 7,
wherein the holder has another projection crashed by abutting against the wall forming slot, the projection and the another projection being offset with respect to a direction perpendicular to the optical axis.

9. The optical transceiver of claim **8**,

wherein the wall forming the slot includes an L-shaped hollow with a first area and a second area, the projection riding on the wall from the first area and the another projection riding on the wall from the second area, and

wherein the projection has a distance from an edge of the first area equal to a distance from an edge of the second area for the another projection.

10. A method to assembly an optical transceiver comprising an optical sub-assembly and a housing, the optical sub-assembly having a box portion to encloses an optically active device therein and a cylindrical coupling portion securing a stub therein and providing an index outer surface and a flange, the stub having an end surface inclined with an optical axis of the stub, the index outer surface indexing an inclined direction of the end surface of the stub, the housing providing a slot and a saddle,

the method comprising steps of:

installing the optical sub-assembly into the housing as inserting the flange into the slot;

rotating the cylindrical coupling portion of the optical sub-assembly around the optical axis such that the index outer surface is uniformly in contact with a top surface of the saddle of the housing; and

inserting a holder into a gap between the flange and a wall forming the slot of the housing such that the holder pushes the flange against another wall forming the slot.

11. The method of claim **10**,

wherein the saddle of the housing provides a pair of ribs,

wherein the step of rotating the coupling portion includes a step of setting the index outer surface of the coupling portion so as to be uniformly in contact with the top surface between the ribs.

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